Design Modules for Corrosion Protection

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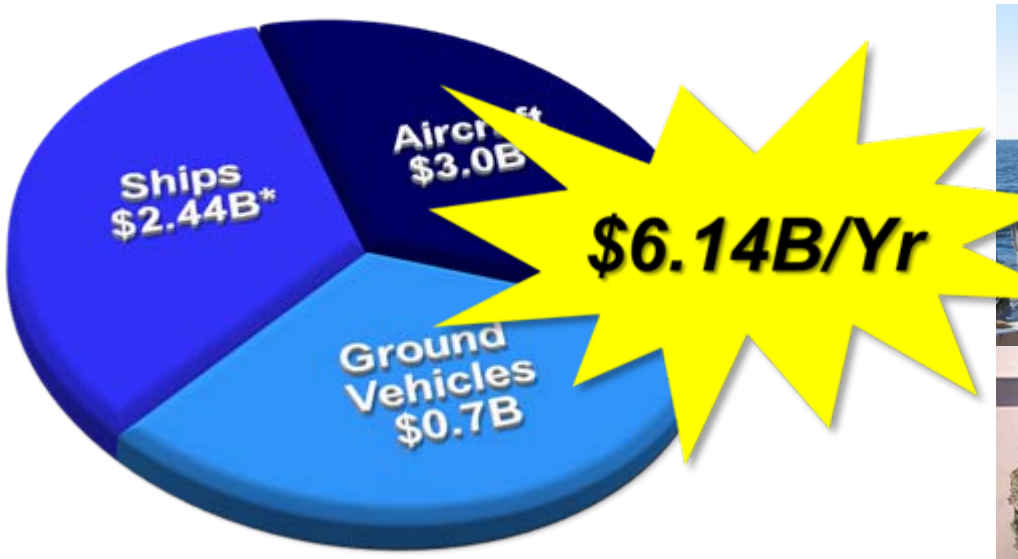
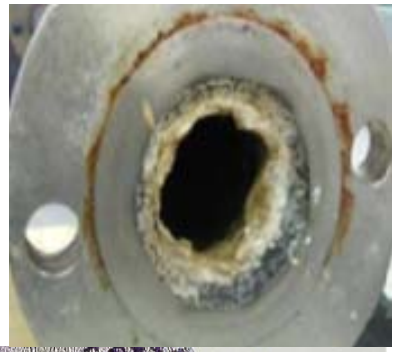
Corrosion is the Navy's No. 1 Maintenance Problem

- ***A*s required by OSD AT&L Office of Corrosion Policy and Oversight, the Duncan-Hunter Act, and DoD Instruction 5000.2, each Service is now required to develop and employ a corrosion control strategy and materials development/ implementation program to reduce the effects and costs of corrosion on DoD assets**





Development Objectives

Design Modules for Corrosion Prevention (DMCP)

A new product development effort to allow platform designers and acquisition professionals to incorporate the corrosion knowledge base as inherent element of component and system design analysis

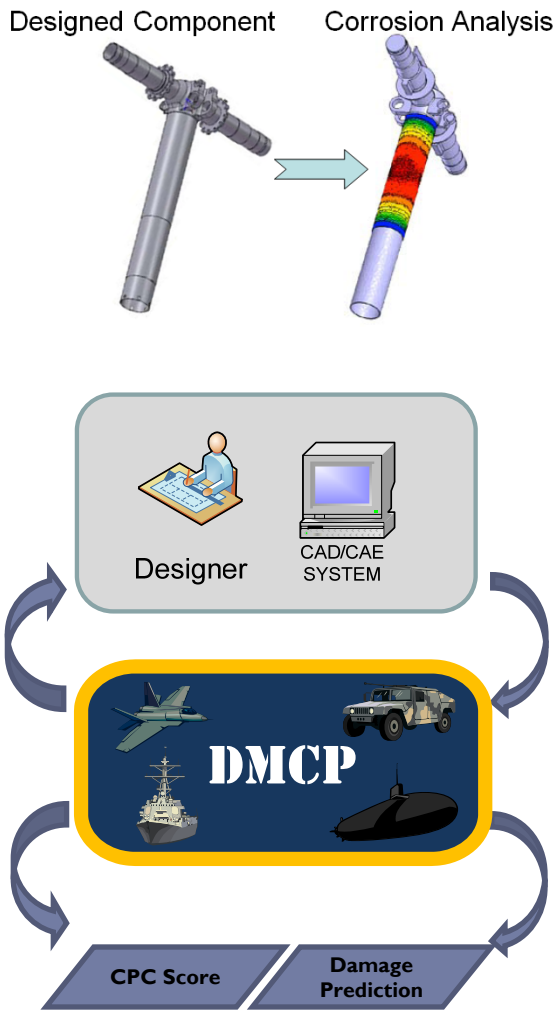
Scope:

- **This effort addresses cross-platform corrosion cost drivers.**
- **This effort targets new solutions for platform specific corrosion challenges.**
- **This effort will enable corrosion informed materials selection and design to reduce total ownership cost (TOC) and to enhance operational readiness.**

Design Modules for Corrosion Prevention

Technical Description:

- **Develop an analytical tool that incorporates algorithms, architecture and automation to enable selection of materials, simulation of corrosion responses and rapid feedback cycle for initial design revisions**
  - **Provide working, integrated component corrosion analyses for Naval design communities**
  - **Achieve 80+% successful prediction of corrosion locations and severities (service life) on selected test case components**
  - **Demonstrate corrosion prevention recommendations on selected test case components**
  - **Demonstrate potential to reduce corrective action maintenance costs caused by poor design practices through improved design review**
- **The deliverable will be DMCP Software**
  - **Corrosion prevention and control (CPC) analyses software accessible to the design engineer**
  - **Transparency of CPC Score for improved technical oversight, design and mitigation**
  - **Risk analysis and mitigation through alternative material selection**

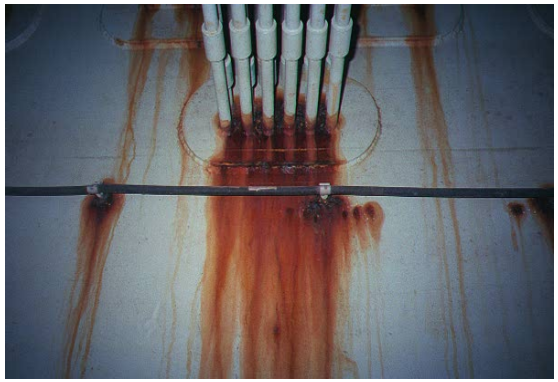


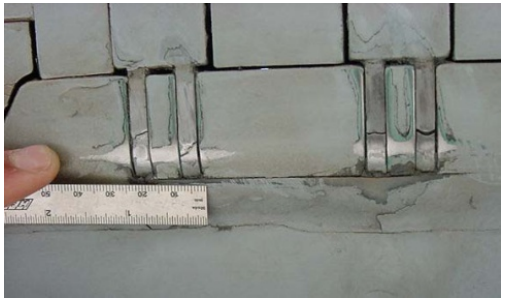
Design Modules for Corrosion Prevention (DMCP)

Problem Description:

OSD mandate regarding corrosion protection input for all ACAT 1 programs (DOD Instruction 5000.2)

- **Navy systems are constructed from a complex system of materials with widely varying corrosion properties**
- **Component and system designers do not have a sophisticated level of corrosion prevention knowledge**
- **Present design process relies on a dwindling number of corrosion subject matter experts reviewing details of relatively mature designs –inefficient and costly**
- **Corrosion costs the Navy $6.6B/yr**
- **Decades of knowledge exist without an efficient mechanism for delivery into the front of the design pipeline**
- **A robust and flexible conduit is needed to deliver known and developing corrosion knowledge into the design process for future Naval platforms**

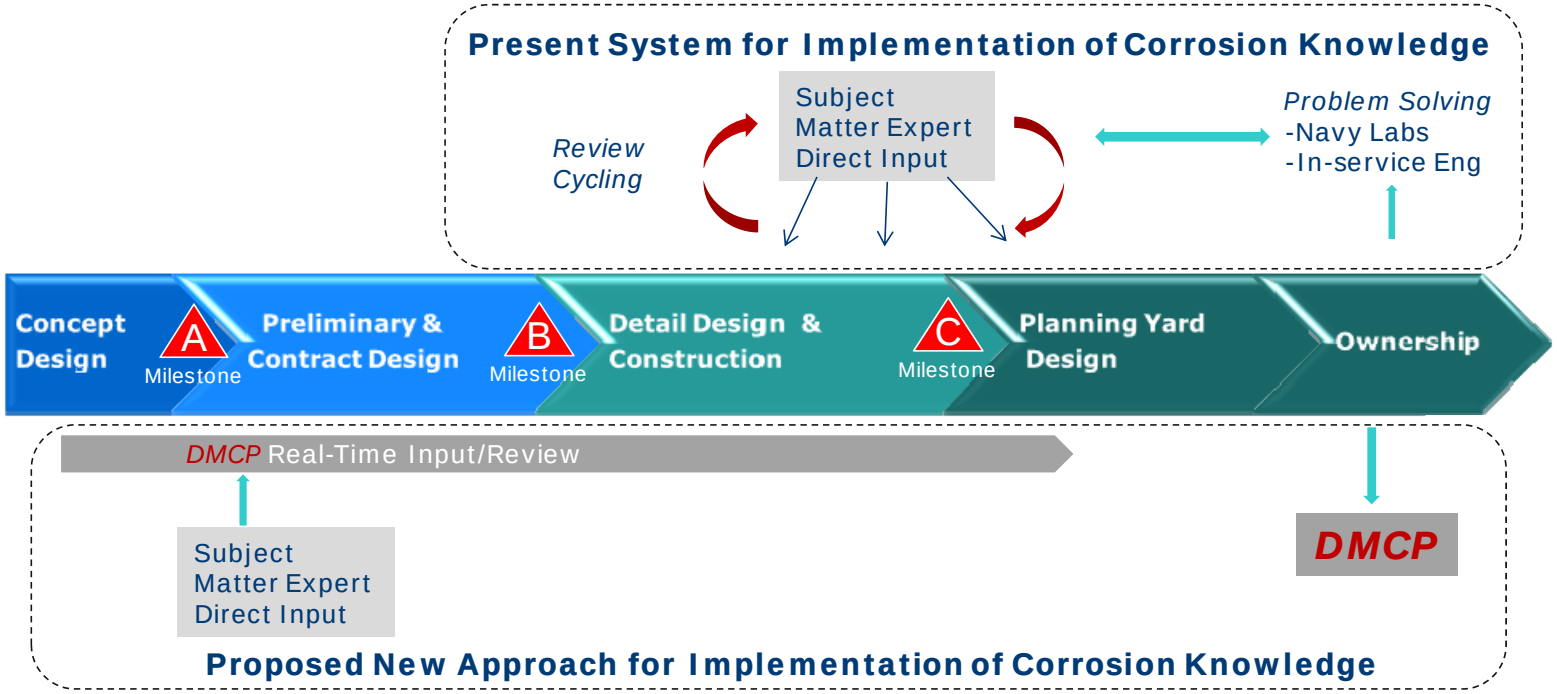




Design Modules for Corrosion Prevention

Rationale for Selection:

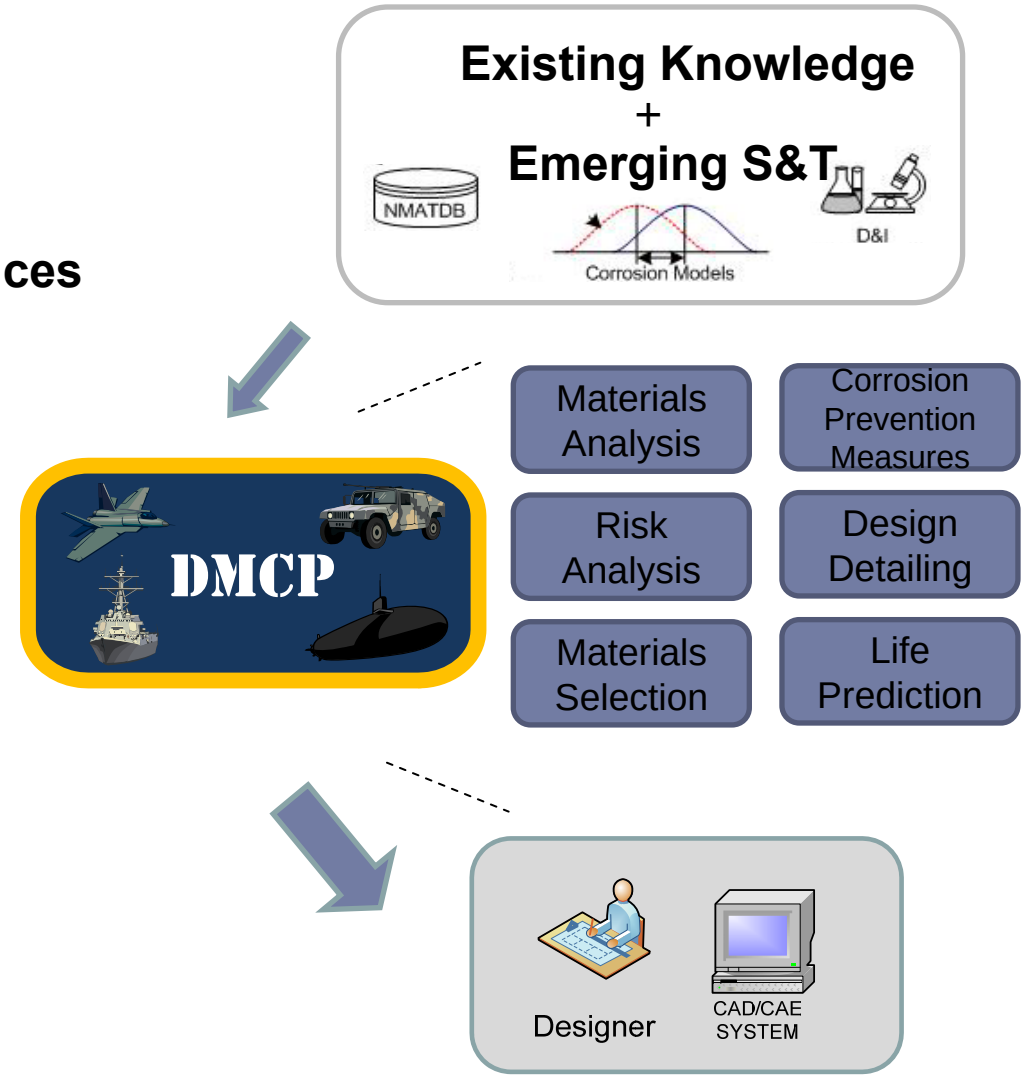
- Navy-wide corrosion issues share a common problem
  - Insufficient consideration for corrosion prevention in the acquisition cycle prior to Milestone B and C
- No technical solutions presently exist to address this challenge
- This EC product will move corrosion prevention inputs forward in the design process, increasing the efficiency and effectiveness of the corrosion review process for new components and systems
- The developed product will provide a future transition path for current S&T in corrosion mechanistic studies and related computational modeling being developed by ONR Code 333



Design Modules for Corrosion Prevention

Underlying Technology:

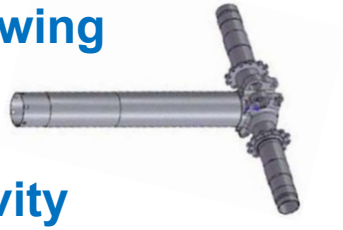
- Existing technologies
  - Historical knowledgebase
  - Design rules and best practices per Naval Ship's Technical Manual (NSTM)
  - Cathodic protection models
- Emerging technologies
  - Navy Materials Database (NMATDB)
  - New materials and coatings
  - Active corrosion countermeasures
  - ONR-developed corrosion behavior models



Design Modules for Corrosion Prevention

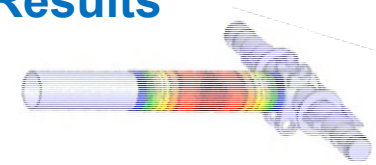
Interaction with DMCP Module:

System/Component Drawing
- Geometry
- Materials & Coatings
- Component Connectivity



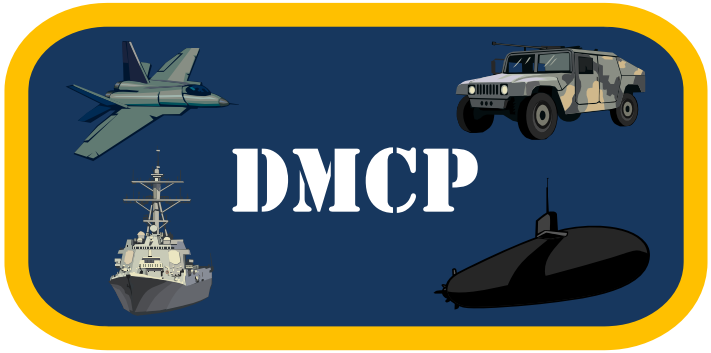
Component Usage
- Environment
- Function
- Maintainability

Corrosion Analysis Results
- Corrosion Risks
- Life Prediction
- Design Revisions



Analysis Inputs

Act as a tool native to the CAD system environment

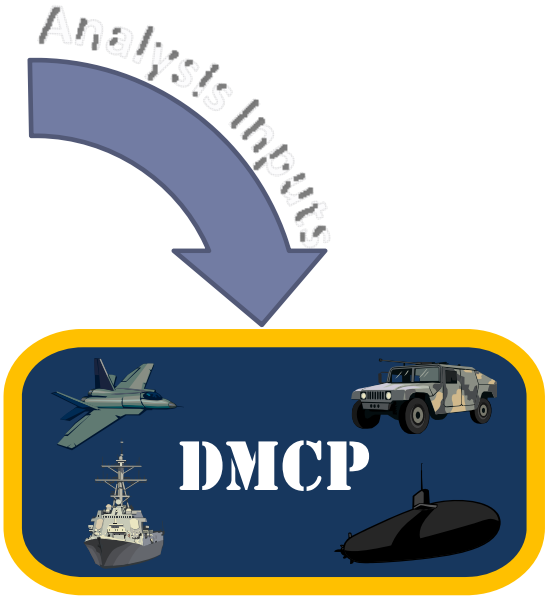


Design Feedback

Assimilate results into overall corrosion risk score

Design Modules for Corrosion Prevention: Analytical Algorithm

Analysis Inputs



Parse CAD Model
Listing of all bulk materials, coatings, surface preparations, lubricants, and inhibitors applied to designed component

Service Environment
Corrosion failure modes are down-selected based on service environment, list of materials, and known phenomena associated with these combinations.

Corrosion Model Selection
Specific corrosion behavior models are invoked by the decision matrix. These behavior models dictate which properties of state must be tracked and modeled in component analysis.

Build Geometric Models
Assembling the corrosion model based on properties of state that must be modeled. Automatic finite element meshing either for surface or for 3-D field distributions.

Surface Conditions in Model
Corrosion models tend to be dominated by non-linearity of corrosion models. Building these response functions into a SOLVABLE matrix will be a challenge.

Initial Condition Model
Corrosion risk analysis is conducted on a "time zero" corrosion damage model.

Initial Results Plots
Results of time-zero analyses are plotted on drawn component surfaces. Output is presented to designer.

Life Prediction Analysis
Progression of corrosion damage is followed through a time-stepping sequence in the corrosion model codes.

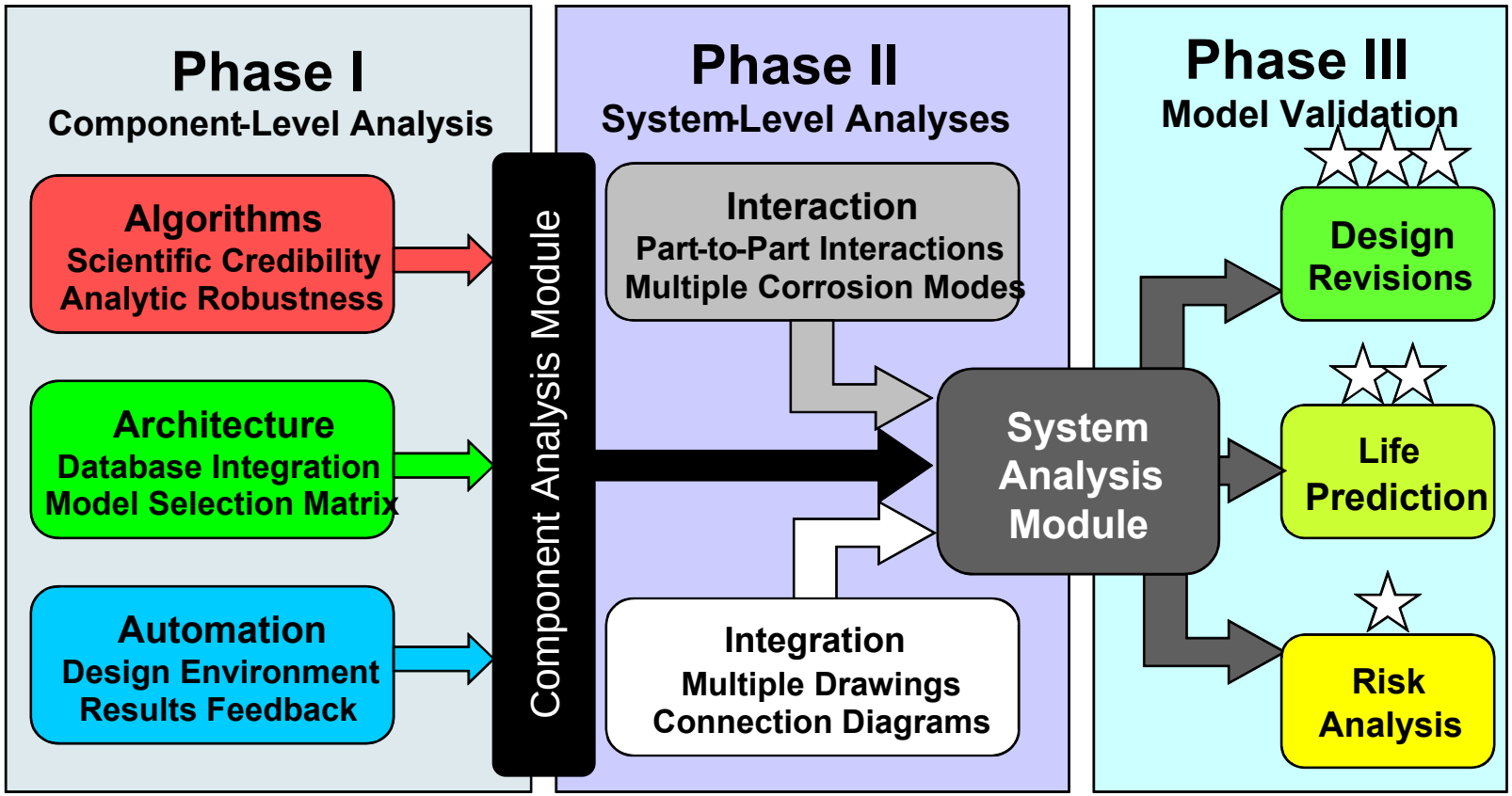
Design Revisions
Results of corrosion risk analysis "what-if" scenarios are compared as alternate materials, coatings, or service environment conditions are considered.

Design Feedback

Design Modules for Corrosion Prevention

Technology Development Plan:

- Identify and resolve known and well established corrosion design flaws during design – prior to delivery in new a Naval operational platform



Design Modules for Corrosion Prevention

Developmental Considerations:

- Algorithms need to be properly validated by real-world component validation tests, under purview of subject matter experts
- Incorporating multiple mechanism stressors and properties (stress, temperature, etc.) in addition to corrosion
- Continued investment in basic scientific models with specific emphasis on robustness
- Model selection matrix needs to be based on service environments – not on esoteric materials science parameters